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Eocene bivalves from the Pallinup Siltstone near Walpole, Western Australia

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Abstract

A western occurrence of the Upper Eocene Pallinup Siltstone is reported from the Walpole district of Western Australia. The deposit occurs as a remnant valley fill at an elevation of 124 m above Australian Height Datum. It contains a diverse molluscan fauna, of which 23 species of bivalves and about 50 species of gastropods have been recognized, preserved mainly as siliceous replacements. There is a good correlation with Late Eocene faunas of south-eastern Australia. Most bivalves represent wide-ranging Eocene genera, while some (*Fasciculicardia*, *Hedecardium* and *Dosina*) are of Austral-Neozelanic affinity. One family (Glossidae) and genus (*Glossus*) are reported from the Australian Tertiary for the first time; 4 genera (*Acar*, *Plicatula*, *Epicodakia* and *Verticordia*) are recorded from the Australian Eocene for the first time. One new species, *Barbatia* (*Acar*) *gunsoni*, is described.

Introduction

The Upper Eocene Pallinup Siltstone, a transgressive marine unit of the Plantagenet Group consisting of siltstone and spongolite, occurs discontinuously along the south coastal region of Western Australia, in the Bremer Basin, between the Esperance and Northcliffe districts (Fig. 1). Near Albany and in the Fitzgerald River area, it conformably overlies the Upper Eocene Werrilup Formation and elsewhere rests directly on Proterozoic rocks of the Albany-Fraser Province (Doepel 1975). The most recent general review of the group is by Cockbain (1968); further information from later studies is provided by Quilty (1974 and references), Geological Survey of Western Australia (1975), and Ludbrook (1977).

Deposition of this and other Middle to Late Eocene marine deposits in southern Australia accompanied downwarping and transgression along the newly-formed continental margin in the aftermath of the geological separation of Australia and Antarctica and the formation of an open seaway between the two continents (Jones 1971, Veevers and Evans 1973). The Pallinup Siltstone formed in a shallow shelf environment with well-circulated water of normal marine salinity (de Laubenfels 1953, Cockbain 1974) and is richly fossiliferous. Sponges, often well preserved, are generally the dominant fossils, but the preservation of what were originally carbonate structures tends to be poor because of pronounced leaching and consequent compaction of the beds.

All specimens from Walpole discussed in this paper are in the collections of the National Museum of Victoria (NMV) and the Western Australian Museum (WAM). In molluscan taxonomy, we have been guided by the Treatise on Invertebrate Paleontology, where available.

Previous work

The first report of non-cephalopod molluscs from the Plantagenet Group appears to be that of Newton (1919), who referred to specimens identified by him as "*Rostellaria*, *Glycymeris* cf. *laticostata* (Quoy and Gaimard) and a Pecten". These were obtained from "the vicinity of Albany" and are presumably in the collection of the British Museum (Natural History).

Glauert's (1926) list, recording 12 bivalve and 3 gastropod species from "Albany and near", "Cape Riche" and "Bremer River", apparently combined Newton's records with the author's identifications of specimens then in the WAM collection. Attempts to locate this material have met with only partial success. The Museum collection contains 11 pieces of yellowish-brown siltstone, bearing impressions of mollusc shells, and labelled "Cape Riche, E of Albany, W.A. Govt. Geologist". Tablets accompanying the specimens are numbered 400 to 409 (405 is missing) but we have been unable to verify these numbers in the records either of the WAM or Geological Survey of Western Australia (GSWA). However, the first palaeontological catalogue of the WAM, started probably in 1897, does appear to record these specimens under the numerical sequence 271 to 281. Identifications on some of the labels and tablets accompanying the specimens and in the catalogue are the same as some of Glauert's published records from Cape Riche and we regard this material as being among that used by him. The history of the Cape Riche collection is obscure, but it may have been associated with Harry P. Woodward, who was Government Geologist in Western Australia from 1887 to 1895. Other fossil material, endorsed "H. P. Woodw. 2nd Colln." is housed in the WAM collections.

More ambitious studies on the Plantagenet Group molluscs are those of Chapman and Crespin (1926, 1934), of which the latter has greater significance. For

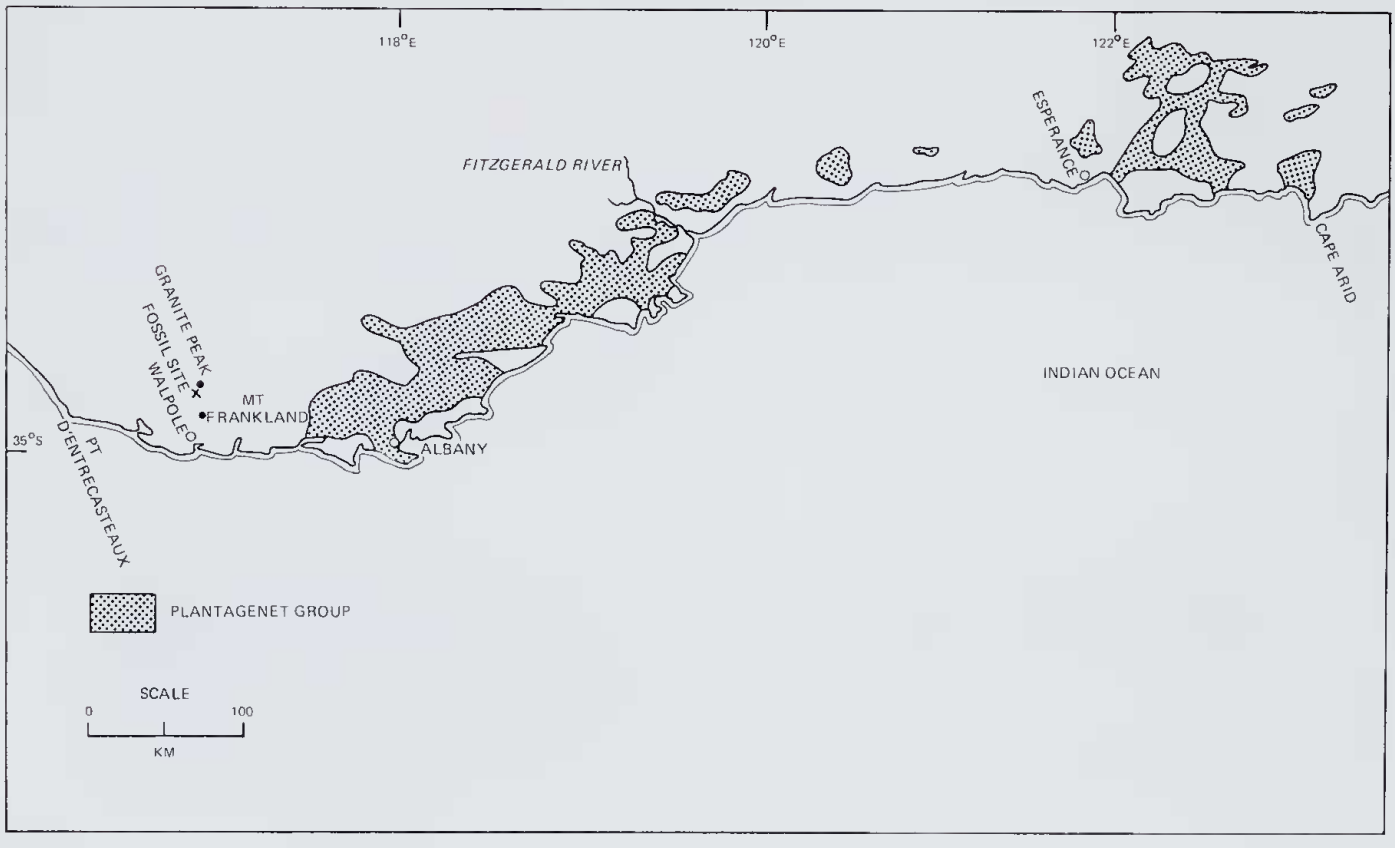

Figure 1.—Locality map. Plantagenet Group outcrops after Cockbain (1968).

their bivalve and gastropod material, Chapman and Crespin (1934) refer to two Western Australian sources. These were "the Glauert collection", actually a combination of specimens from WAM and GSWA and "the Jutson collection", housed in the National Museum of Victoria (NMV). Several South Australian and Victorian specimens from the Dennant Collection, NMV, were also cited in this paper but are of no present relevance. Chapman and Crespin excluded all of Newton's and most of Glauert's identifications from their results. A comprehensive review of the Chapman-Crespin determinations lies beyond the scope of the present paper and we do not propose to examine all in detail. We will deal however with certain aspects of their results that have come to notice in the course of our studies.

Forty four bivalve and 24 gastropod species were recorded for the Plantagenet Group by Chapman and Crespin (1934), for which, they determined a Miocene age. However, 9 of their records are from "Balladonia" and probably originated in the Nullarbor Limestone of the Eucla Group; these are discussed further below. Six other records from "Norseman" may be attributed confidently to the Eundynie Group. With the deletion of these 15 records, their corrected totals of Plantagenet Group species stand at 34 bivalves and 21 gastropods.

We have located in the WAM collection a group of 5 fossil molluscs, of which the associated labels are inscribed as follows: 6049 cast of *Diplodonta* sp., 6050 cast of *Dosinia* sp., 6052 cast of ? *Fusinus* sp., 6053 *Conus ligatus* Tate and 6054 *Seraphs* sp. Their locality, entered in the catalogue on 3 October 1927, is "Bremer Bay" and it appears that these specimens account for 5 of the 6 records from there in Chapman's and Crespin's (1934) list. The sixth record, "*Crassatellites ? sulcatus* Sol.", cannot be traced further but presumably represents the missing specimen 6051. The 5 available specimens are all internal casts in a hard, pale brown limestone and are covered with sparry calcite. This lithology is unknown within the Plantagenet Group but matches closely that of WAM specimens 3247-3263, collected by W. B. Alexander at Balladonia, evidently from the Nullarbor Limestone.

The original catalogue entry for Alexander's specimens, made on 30 June 1914, comprises 17 numbers, without identifications. However, we note that Chapman and Crespin recorded only 11 species from Balladonia (1 foraminifer, 1 brachiopod, 9 molluscs) and 6 from "Bremer Bay". The lithology of the latter is foreign to the Plantagenet Group but consistent with that of the Nullarbor Limestone and we consider them to be the missing part of Alexander's original Balladonia collection. This confusion evidently arose between June 1914 and October 1927, before the material was seen by Chapman and Crespin. In view of the foregoing, we delete all 6 of the "Bremer Bay" records from their 1934 list, thus reducing their total of species validly attributed to the Plantagenet Group to 31 bivalves and 18 gastropods.

The WAM fossil collection contains 2 small pieces of friable, ferruginous sandstone bearing impressions of bivalve exteriors. An original label, numbered 6046, gives the locality "King River"; a second label in Dr Crespin's hand, is inscribed *Antigona* cf. *hormophora* (Tate). One piece (now 6046b) has attached a small, complete specimen of the living estuarine mytilid bivalve *Xenostrobus securis* (Lamarck) and both pieces show numerous small fragments of shelly material entrapped within what appear to be modern, mytilid byssal fibres. We consider that this material was collected from a modern, inter-tidal estuarine locality, such as can be

found at Lower King, Albany, near the northern end of Oyster Harbour. The shell impressions retained on the sandstone represent, in our view, the common venerid cockles *Katelysia scalarina* (Lamarck) and *K. rhytiphora* Lamy and not the Tate species from Table Cape.

The original catalogue entry for number 6046 shows it to be one of a sequence of three lots (6044-6); none is otherwise identified and we have been unable to locate specimens 6044 and 5 in the collection. Chapman and Crespin (1934, p. 126) list 3 species from "King River", *Antigona* cf. *hormophora* (Tate)", "*Lithophagus* sp." and "*Tellina* sp.", but without citing catalogue numbers. Their "*Lithophagus* sp." is described as "an ironstone cast", which suggests a relationship with the *Katelysia* specimens of 6046. There being no differentiation within the catalogue for specimens 6044-6, it is reasonable to assume that they were obtained from a common source and we consider it most unlikely that any of these specimens originated in sediments of the Plantagenet Group. The deletion of the three "King River" records from Chapman's and Crespin's list would reduce their total of species to 28 bivalves and 18 gastropods.

The collection of the GSWA contains a group of 23 pieces of Pallinup Siltstone, numbered in the sequence $\frac{1}{4131}$ to $\frac{1}{4136}$ (excluding $\frac{1}{4135}$). These were seen by Chapman and Crespin and listed by them on p. 107. The specimens include moulds and casts of bivalves, gastropods and nautiloids; the first-mentioned include what appear to be poorly preserved examples of *Barbatia limatella* Tate, *Glans latissima* (Tate) and others, unidentified.

We have located in the collection of NMV 5 bivalves and 8 gastropods from the Pallinup Siltstone, part of "the Jutson collection" of Chapman and Crespin. The bivalves are poorly preserved, though 3 are determinable to genus (*Glycymeris* sp. and *Chlamys* spp.). None of these specimens appears to have any direct relevance to our Walpole material and will not be considered further in this paper.

It has been shown above that a substantial part, about one third, of the Chapman and Crespin records were derived from sources other than the Plantagenet Group. We have been able to locate and examine part of the remainder of their material but are unable to confirm any of their bivalve identifications. As an account of bivalve species attributable to the Plantagenet Group, we consider that the Chapman and Crespin paper lacks validity. Some of their gastropods, however, appear to have been identified correctly and this will be discussed by us in a further contribution.

Locality details

The fossil material here discussed was collected by the authors and associates from a deposit first made known to GWK in 1967 by Mr L. Gunson of the National Parks Authority of Western Australia, Walpole. It is located beside the Thompson Highway 26 km by road north from Walpole townsite (latitude 34°48′S, longitude 116°43′E; Pemberton 1:250 000 map sheet grid reference 472703). A preliminary report on the deposit and its fauna was presented by Darragh (1973).

At the fossil site, Thompson Highway crosses a low-lying poorly-drained sandy depression several hundred metres wide, which extends for a much greater distance westward, where it connects with a tributary of the Deep River. An embankment has been constructed to carry the road across the lowest part of the depression, utilizing rock and sand obtained from shallow excavations along either side of the road. Initially, fossils were found on the disturbed surfaces of these excavations and the deposit was subsequently authenticated by sampling adjacent undisturbed ground. The undisturbed sequence comprised up to 1 m of white to brown siliceous silty sand, intensely humic near the surface, the lower third of which contained abundant sponge remains, together with occasional molluscan shells, echinoid spines, brachiopods, bryozoans, hydrozoans, scleractinian corals, annelid tubes and otoliths. The fossiliferous sand merged into an irregularly surfaced, greyish-brown, well-sorted, sandy siltstone containing similar fossils. We found no evidence of post-depositional transportation of the fossiliferous sand, which we consider to be residual and derived *in situ* by weathering from the underlying unit. To this process, acidic ground water has probably contributed.

Although the site is enclosed on three sides by lateritized hillslopes, we have found no trace of any lateritic material in sievings from the fossil bed. The depression is densely vegetated and slopes gently to the west. The fossil deposit, of unknown thickness, apparently fills the lowest part of this depression, which may represent part of an early Tertiary or older drainage system, such as has been noted with disjunct Eocene marine deposits in other parts of southern Western Australia (Lowry 1970).

Measurements made with a 2·5 inch surveying aneroid barometer indicate that the top of the fossil bed lies at 124 m above Australian Height Datum (equivalent to mean sea level) (S.A. Wilde, pers. comm.). This is well within the upper limit of 300 m established by Lowry (1970) and others for the Late Eocene shoreline in this region.

Faunal details

Preservation

The deposit and its associated fossils are strongly silicified and entirely leached of carbonate. Sponges have retained substantially their original form and texture in grey silica, whereas the molluscs and other groups are preserved as translucent brown (occasionally opaque white) replicas of the original carbonate structures. The most common mollusc species, *Tenagodus* sp. cf. *T. occlusus* Tenison Woods, has been collected in situ within pieces of sponge, indicating that the Eocene habitat of the genus was similar to that of modern forms.

Darragh (1973) considered that the silica of the Walpole molluscs had been precipitated as casts within natural moulds but subsequent examination of a wider range of material has led to a reconsideration of this view. The retention of the original internal structure in echinoid spines, together with the presence of residual nacreous lustre in some archaeogastropod shells, suggests rather that the specimens are molecular replacements of carbonate by silica. Cavity infillings of silica occur in a proportion of both bivalve and gastropod shells; where present, these are usually well differentiated by colour from the "shells" and appear to have been formed at a different time. Under microscopic examination, it may be seen that fidelity in reproduction varies somewhat; many specimens appear to have lost at least some finer detail, though the major features of the shells are often very well preserved. Distortion,

due apparently to compaction of the enclosing sediment, has affected a proportion of the specimens; others seem to have been abraded or damaged prior to fossilization.

In the sandy siltstone underlying the fossiliferous sand, sponges are preserved as grey to brown, often vitreous bodies, in which the internal structure may be clearly visible on broken faces. Other originally-carbonate fossils may occur either as brown, glassy replacements (silica) or as natural moulds. The latter form is more typical of fossil preservation in the Pallinup Siltstone generally and it is this, together with distortion of specimens, that has discouraged interest in the molluscs hitherto. The present material from Walpole is the first obtained from this source, in which the original shell forms or something close to them, can be examined directly. What appears to be similar preservation in Eocene molluscs from South Australia has been reported by Basedow (1904).

Palaeoecology

Oceanic temperatures to the south of Australia during the Eocene appear generally to have been somewhat higher than at present (see Kemp 1978). The presence in the Plantagenet Group of the foraminifer *Asterocyclina* (Cockbain 1967), the alga *Neomeris* (Cockbain 1969), mangroves and other tropical vegetation (Churchill 1973) and certain echinoids (Foster 1974) are in accord with this conclusion. From the Late Palaeocene, through the Eocene and Early Oligocene, surface sea temperatures in this region, though oscillating somewhat, show a general decline (Shackleton and Kennet 1975) and there is evidence of a progressive cooling within the Late Eocene Blanche Point Formation and Port Willunga Beds of the St. Vincent Basin (Daily *et al.* 1976). No such trend has as yet been demonstrated within the Plantagenet Group; however our studies on bivalve and gastropod molluscs from Walpole suggest a fauna of temperate character, deficient in traditional tropical elements but with a high proportion of cosmopolitans. We emphasise that our evidence is drawn from a single locality only and is unlikely to be representative of the molluscan fauna of the formation and group as a whole. The presence of numerous herbivorous archaeogastropods and cerithiaceans supports the view that the site at the time of deposition was located on the inner shelf in relatively shallow water. At the time, adjacent hills such as Mt Frankland (411 m), Granite Peak (403 m) and other elevated areas would have formed temporary islands and shoals, around which a diversity of molluscan habitats and life would have become established.

The presence of predatory gastropod boreholes in molluscan specimens has been noted and will be dealt with in a later paper, describing the gastropod fauna. In the recognition of naticiform and muriciform boreholes, we have followed Carriker and Yochelson (1968). Briefly summarized, the bivalve predation data show that of 658 specimens examined, 61 (9·2%) had completed gastropod boreholes, of which 12 (1·8%) were naticiform and 49 (7·4%) were muriciform.The principal prey species were *Arcopsis dissimilis* (1 naticiform, 15 muriciform boreholes), *Limopsis chapmani* (7 naticiform, 11 muriciform), *Plicatula* sp. (10 muriciform) and *Glans latissima* (4 muriciform).

Correlation

Chapman and Crespin (1926, 1934) correlated the Plantagenet Group fauna with that of the Tasmanian Lower Miocene Table Cape Group. However, we consider most of their molluscan identifications to be erroneous, there being little affinity with the molluscs of the Table Cape fauna, reviewed recently by Ludbrook

Table 1

Occurrences of Walpole bivalve species in other Tertiary formations in southern Australia; references in text. 1, *Wilson Bluff Limestone* (*Eucla Basin*). 2, *Tortachilla Limestone and* 3, *Blanche Point Formation* (*St. Vincent Basin*). 4, *Brown's Creek Clay and* 5, *Jan Juc Formation* (*Otway Basin*). 6, *Freestone Cove Sandstone* (*Bass Strait*).

Species	Formations and age						Remarks
	Eocene				Oligocene	Miocene	
	1	2	3	4	5	6	
Nucula tatei Finlay			*	*			
Nuculana (*Saccella*) *chapmani* Finlay			*	*			
Arca pseudonavicularis Tate			*	*			
Barbatia (*B.*) *limatella* Tate			*	*			
Barbatia (*Acar*) *gunsoni* sp. nov.							Known only from Pallinup Siltstone.
Arcopsis dissimilis (Tate)			*	*			
Limopsis chapmani Singleton			*	*	*		
Limopsis multiradiata Tate ?							*L. multirudiata* recorded from 3 and 4.
Septifer sp. cf. *S. fenestratus* Tate							*S. fenestratus* recorded from Muddy Creek Marl and Balcombe Clay (Middle Miocene).
Vulsellu laevigata Tate		*					
Plicatula sp.							Known only from Pallinup Siltstone.
Spondylus sp. cf. *S. gaderopoides* McCoy							*S. gaderopoides* recorded from 1, 3, 5, 6, etc.
Dimya sigillata Tate	*		*	*			
Limeu (*Gemellimu* ?) sp.							Known only from Pallinup Siltstone.
Limid. genus and species undetermined							Known only from Pallinup Siltstone.
Epicodakia sp.							Known only from Pallinup Siltstone.
Glans (*Fasciculicardia*) *latissima* (Tate)			*	*			
Sulaputium communis (Tate)			*	*			
Vepricardium (*Hedicardium*) *moniletectum* (Tate)?							*V.* (*H.*) *moniletectum* recorded from 3.
Glossus (*Miocardiopsis*) sp.							Known only from Pallinup Siltstone.
Dosina multilamellata (Tate)			*	*	*	*	
Corbula (*Caryocorbula*) *pixidata* Tate			*	*			
Verticordia sp.							Known only from Pallinup Siltstone.
Totals	1	1	11	11	2	1	

(1973). A Late Eocene age for the Plantagenet Group was recognized first by Glaessner (1953) from the presence of the nautiloid *Aturia clarkei* Teichert and has been confirmed by all subsequent studies, for example, those by Cockbain (1967), Quilty (1969) and Backhouse (1970) on foraminifers, by Cockbain (1968) on nautiloids and by Hos (1975) on plant microfossils.

From Walpole, we recognize 23 species of bivalves, of which at least 11 are known both from the Late Eocene Blanche Point Formation of the St Vincent Basin and from the Brown's Creek Clay of the Otway Basin; 7 of the bivalve species are known only from the Pallinup Siltstone. Gastropods number about 50 species, of which 27 are known from the South Australian-Victorian formations and others are closely related to species occurring there. In general, Walpole specimens tend to be a little smaller in size than corresponding forms at Brown's Creek. New species, mainly cerithiaceans and sponge-dwellers, total about 23; this is not unexpected in view of the geographic isolation of Walpole from the South Australian-Victorian localities.

The stratigraphic position of the Eocene fossils from the Adelaide (i.e., Kent Town) Bore described by Tate (1886, 1887) has been discussed by Lindsay (1969), Ludbrook (1973) and revised by Cooper (1977). Following the last-mentioned, we refer these occurrences to the lower part of the Blanche Point Formation. A general correlation is therefore indicated with the Blanche Point Formation, Tortachilla Limestone and Brown's Creek Clay (Table 1). These lie wholly or substantially within the Aldingan Stage of Ludbrook and Lindsay (1966) and planktonic foraminiferal zones P15, P16 and P17 (Ludbrook 1973).

Most of the bivalve genera from Walpole are cosmopolitan in distribution, with related or similar species occurring in the Eocene of New Zealand, Asia, Europe and America. *Fasciculicardia*, *Hedecardium* and *Dosina* are genera common to Australia and New Zealand, which have their major representation in New Zealand. *Miocardiopsis* has been recorded previously from the Eocene of Europe but the genus and family (Glossidae), have not been reported hitherto from the Australasian Tertiary. Four other genera, *Acar*, *Plicatula*, *Epicodakia* and *Verticordia*, are also recorded for the first time from the Australian Eocene; species of all 4 genera are known from later Cainozoic faunas in southern Australia.

Systematic descriptions

Bivalvia

Family Nuculidae

Genus **Nucula** Lamarck 1799

(**Pronucula** Hedley 1902)

We follow Bergmans (1978) in placing *Pronucula* Hedley in synonymy with *Nucula* Lamarck.

Nucula tatei Finlay

(Fig. 2 A-D)

1924 *Nucula tatei* Finlay: p. 107 *nom nov* for *Nucula semistriata* Tate *non* Wood.

1961 *Pronucula tatei;* Ludbrook, p. 56, pl. 1 figs. 5, 6.

Type locality: Blanche Point, Aldinga Bay, South Australia (Ludbrook 1961); Blanche Point Formation (Cooper 1977).

Material: WAM 67.94, 69.104, 74.540, 78.4083. NMV P40631, P40651.

Remarks: This species is represented by 4 articulated pairs, all deformed, 6 left and 9 right valves. Anterior/posterior hinge tooth counts of three valves are 15:8, one has 14:8 and one has 12:7; radial micro-sculpture is present on the ventral areas of the larger specimens only. Length 6·2, height 5·4, inflation (one valve) 1·2 mm. Walpole specimens agree well with topotypes. A range of variation in shell proportions is shown in the figures. Uncommon at Walpole.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay and Pallinup Siltstone; Late Eocene.

Family Nuculanidae

Genus **Nuculana** Link 1807

Subgenus **Saccella** Woodring 1925

Nuculana (Saccella) chapmani Finlay

(Fig. 2 E, F)

1924 *Nuculana chapmani* Finlay: p. 107 *nom nov* for *Leda apiculata* Tate *non* Sowerby *nec* Reuss.

1961 *Nuculana (Saccella) chapmani;* Ludbrook p. 57, pl. 2 figs. 1, 2.

Type locality: Blanche Point, Aldinga Bay, South Australia; Blanche Point Formation (Cooper 1977).

Material: WAM 67.74, 69.103, 72.260, 74.541, 74.549, 78.4084. NMV P40636, P40653.

Remarks: Altogether 126 specimens (44 articulated pairs, 44 left and 38 right valves) represent this species from Walpole. The valves have rather weak transverse ribbing similar to the majority of specimens from Brown's Creek, rather than the well developed ribbing characteristic of most from the type locality; the chondrophore is deep and proportionately wide. Length 8·6, height 5·5, inflation (one valve) 2·0 mm. Though one of the more common species at Walpole (comprising 1 in 5 of all bivalves), only 3 specimens show evidence of gastropod predation. No specimen obtained from Brown's Creek shows a gastropod borehole.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay and Pallinup Siltstone; Late Eocene.

Family Arcidae

Genus **Arca** Linnaeus 1758

Subgenus **Arca** s. s.

Arca (Arca) pseudonavicularis Tate

(Fig. 2 G)

1886 *Arca pseudonavicularis* Tate: p. 139, pl. 11 fig. 8.

1965 *Arca pseudonavicularis;* Ludbrook p. 94–5, pl. 3 figs. 30–31.

Type locality: Adelaide (i.e. Kent Town) Bore, at 45·7–66·4 m (Ludbrook 1965). This lies within the lower part of the Blanche Point Formation as defined by Cooper (1977).

Material: WAM 67.87, 74.542, 78.4085, NMV P40648.

Remarks: The 4 available lots comprise a substantially complete right valve and some fragments. These show well-defined radial sculpture on the postero-dorsal area and a predominantly transverse sculpture elsewhere. Our figured specimen has the umbo located at about the anterior fifth. The species is uncommon at Walpole.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay and Pallinup Siltstone; Late Eocene.

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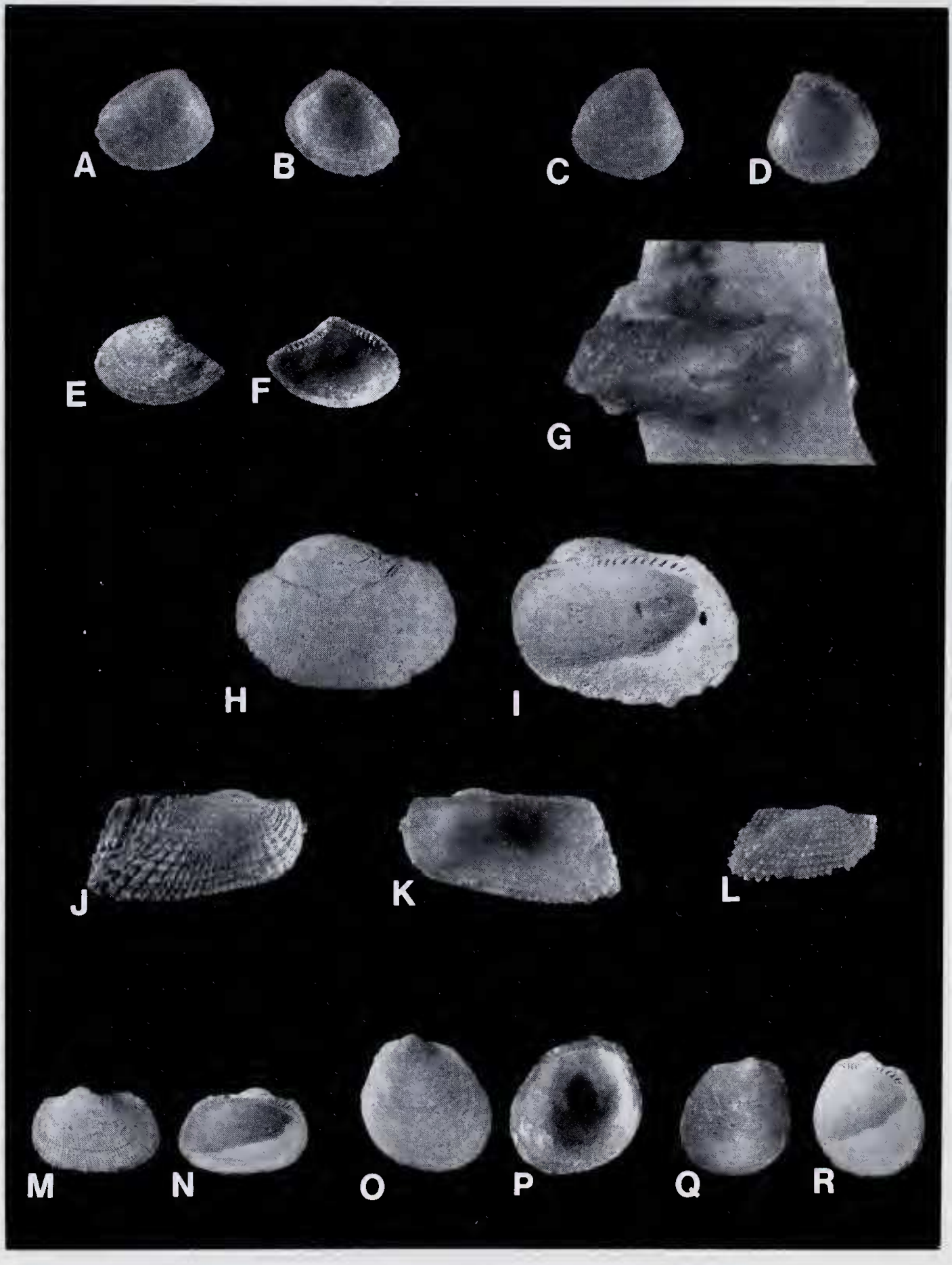
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Genus **Barbatia** Gray 1842

Subgenus **Barbatia** s. s.

Barbatia (Barbatia) limatella Tate

(Fig, 2 H, I)

1886 *Barbatia limatella* Tate: p. 141–142, pl. 10 fig. 2.

1965 *Barbatia (Barbatia) limatella:* Ludbrook p. 97, pl. 3 figs. 21–23.

Type locality: Adelaide (i.e. Kent Town) Bore at 45·7–66·4 m (Ludbrook 1965); Blanche Point Formation (Cooper 1977).

Material: WAM 67.46, 67.47. 72.262, 72.265, 74.538, 74.543, 78.4086. NMV P40637, P40644.

Remarks: The available specimens from Walpole comprise 1 deformed pair, 3 lefts, 2 right and 10 fragmentary valves; also 2 internal moulds in grey, silicified siltstone. Length 17·0, height 12·7, inflation (one valve) 6·0 mm. Walpole specimens generally differ from topotypes and those from Brown's Creek in that the sculpture is not as prominent. This may be an artifact of preservation or due to abrasion of the valves, rather than any true morphological variation. The figured specimen comes closest to those from South Australia and Victoria.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay and Pallinup Siltstone; Late Eocene.

Subgenus **Acar** Gray 1857

Barbatia (Acar) gunsoni sp. nov.

(Fig. 2 J-L)

Type Locality: Walpole, Western Australia. Sandy depression 26 km north from Walpole townsite along Thompson Highway; sieved from grey, silty sand overlying brown siltstone. Latitude 34°48′S Longitude 116°43′E. Pallinup Siltstone.

Material: Holotype WAM 78.4087a, a single right valve. Paratypes WAM 67.75a, 69.105a–b, 72.263, 74.544, 78.4087b-d, 78.4088a-b, NMV P40635, P40647, P56030.

Diagnosis: A small, compressed *Acar* with height equal to half the length; sculpture of fine, transverse lamellae (17 in a height of 5·3 mm); radials mostly subordinate, narrow, discontinuous and scaled in the median area, wider anteriorly; posterior area sculpture usually predominantly radial and beaded where crossed by the lamellae; marginal crenulations becoming obsolete anteriorly; anterior adductor scars subcircular.

Description: A small, rather compressed *Acar*, transversely elongate, trapezoidal and with a weak median sulcus. Anterior margin short, obliquely curved and passing into the slightly convex and sinuate ventral margin, which diverges posteriorly from the hinge margin; posterior margin straight, obliquely truncate, forming an obtuse angle with the hinge margin and an acute, rounded angle ventrally; hinge margin straight, about four fifths of the overall length. Posterior carination well defined; posterior area small, winged; umbones broad, flattened, situated at the anterior fourth; beaks incurved. Hinge slender, narrow medially, widening toward each end; teeth fine, evenly graded and oblique, very finely serrate; in the holotype, the anterior series has 8 teeth, in the posterior, 20. Ligamental area smooth, narrow, weakly recessed and tapering posteriorly. Anterior adductor scar subcircular, the posterior larger and transversely ellipsoidal; both located close to the hinge plate and raised slightly above the inner surface of the valve. Margins, except for the hinge margin, narrowly rimmed and lightly crenulated within; crenulae tending to be obsolete antero-ventrally or below the beaks. Sculpture of the median area predominantly transverse with thin, close, imbricating lamellae (17 discernible in a height of 5·3 mm), fimbriated by narrow, discontinuous radial riblets, the number increasing with growth and bearing low, crowded transverse scales; on the posterior carination, both transverse and radial elements are accentuated. Anteriorly, the sculpture resembles that of the median area but the radials are wider and may be beaded. Sculpture of the posterior area is usually distinct from the median, being predominantly radial; costae are often beaded where crossed by the transverse lamellae; occasionally the posterior sculpture approximates to that of the median area.

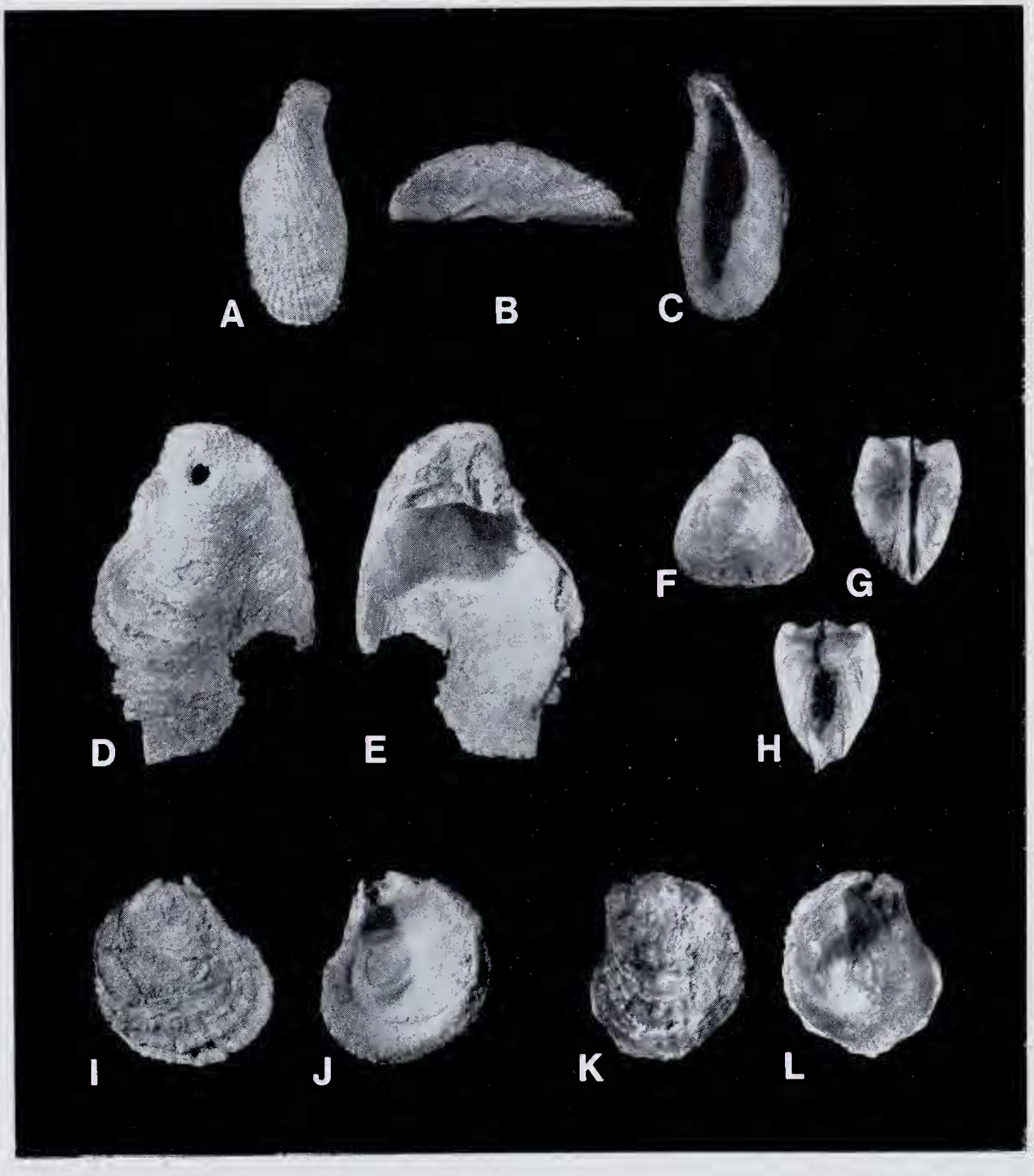
The holotype, a slightly worn right valve and the largest known specimen, has dimensions: maximum length 10·8, length of hinge margin 8·8, height 5·3, inflation (1 valve) 2·2 mm. It is complete but for a small portion of the antero-dorsal extremity; crenulation is obsolete along the entire anterior portion of the ventral margin. Paratype 78.4087b (Fig. 2 L) is an unworn right valve, on which the sculpture of the posterior area is predominantly transverse, with fine, imbricating lamellae and discontinuous radials, as on the median area.

Remarks: The available material comprises 7 right and 6 left valves plus a number of fragments. It appears to be rather uncommon at Walpole; 2 specimens show naticiform boreholes.

The new species most resembles *Barbatia* (*Acar*) *celleporacea* Tate, which occurs widely from the Early Miocene to Late Pliocene of south-eastern Australia (Ludbrook 1965). From the degree of similarity between the two, we suggest that *gunsoni* may be ancestral to Tate's species. The two may be distinguished by differences in overall proportions, size, sculpture, marginal crenulation and possibly also the shapes of the adductor scars. In *gunsoni*, the valves are shorter relative to the height, resulting in a less transversely elongate outline; Tate's species is by far the larger, with specimens as long as 27·5 mm known. The new species has a finer, more imbricate or lamellate sculpture, in which the transverse element tends to predominate; where radials are the more prominent, they carry strong beading, unlike the subnodulose sculpture of *celleporacea*. In both species, there is a tendency for crenulation of the ventral margin to become obsolete anteriorly or below the beaks; crenulation is generally weaker and given more to obsolescence in the present species, though this may be due in part to imperfect preservation and/or wear. The anterior adductor scar is near circular in *gunsoni* but more roundly sub-quadrate in *celleporacea*.

The present records from Walpole are the first reported occurrence of the subgenus *Acar* from the Australian Eocene and the oldest from the Australasian region. An internal cast of a small arcid (WAM 75.24), consistent with *B.* (*A.*) *gunsoni* has been collected from the Werrilup Formation (Nanarup Limestone Member) at the Nanarup lime quarry near Albany and may extend the stratigraphic range of the species a little lower.

Figure 2.—A, B—*Nucula tatei* Finlay. WAM 78.4083a. LV, x 3. C, D—*N. tatei*. WAM 78.4083b. LV, x 3. E, F—*Nuculana* (*Saccella*) *chapmani* (Finlay). WAM 74.549a. LV, x 3. G—*Arca pseudonavicularis* Tate. WAM 78.4085. RV, x 2.8. H—*Barbatia* (*B.*) *limatella* Tate. WAM 72.262. LV, x 2. I—*B.* (*B.*) *limatella*. WAM 74.543a. RV, x 2. J, K—*Barbatia* (*Acar*) *gunsoni* sp. nov. Holotype WAM 78.4087a. RV, x 3. L—*B.* (*A.*) *gunsoni* sp. nov. Paratype WAM 78.4087b. RV, x 3. M, N—*Arcopsis* (*A.*) *dissimilis* (Tate). WAM 72.261a. LV, x 2. O, P—*Limopsis* (*L.*) *chapmani* Singleton. WAM 74.545b. LV, x 2. Q, R—*L.* (*L.*) *chapmani*. WAM 74.545a. RV, x 2.



Chapman and Crespin (1926, 1934) list from Albany an "*Arca* sp.", which they compare with *Barbatia celleporacea*. We have located this specimen (P42476) in the Jutson collection of the National Museum of Victoria and consider that it is not an arcid. It could possibly be a *Miocardiopsis*, a species of which is discussed below.

The new species is named after Mr Lionel Gunson of the Western Australian National Parks Authority, Walpole, who was responsible for bringing this deposit to our notice and who provided hospitality and assistance with field work on a number of occasions.

Stratigraphic range: Pallinup Siltstone, Werrilup Formation (Nanarup Limestone Member)?; Late Eocene.

Family Noetiidae

Genus **Arcopsis** von Koenen 1885

Subgenus **Arcopsis** s. s.

Arcopsis (Arcopsis) dissimilis (Tate)

(Fig. 2 M,N)

1886 *Barbatia dissimilis* Tate: p. 140, pl. 11 figs. 4, 5.

1965 *Arcopsis dissimilis;* Ludbrook, p. 95–6, pl. 5 figs. 26–30.

Type locality: Adelaide (i.e. Kent Town) Bore at 45·7–66·4 m (Ludbrook 1965); Blanche Point Formation (Cooper 1977).

Material: WAM 67·76, 69.106, 72.261, 74.547, 74.548. NMV P40634, P40654.

Remarks: This is a common species at Walpole, the recovery comprising 10 articulated pairs, 46 left and 53 right valves. Right valves show granose radial sculpture on the anterior and posterior dorsal areas only, elsewhere having close transverse ribs bearing low spines, which show a weak radial alignment. Some right valves are smooth medially. The left valve bears strong radial costation all over, crossed by fine transverse sculpture forming low scales upon the ribs. Length 10·2, height 6·5, inflation (one valve) 2·8 mm. The material bears 9 muriciform and 8 naticiform boreholes.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay and Pallinup Siltstone; Late Eocene.

Family Limopsidae

Genus **Limopsis** Sassi 1827

Subgenus **Limopsis** s. s.

Limopsis (Limopsis) chapmani Singleton

(Fig. 2 O–R)

1932 *Limopsis chapmani* Singleton: p. 296–9, pl. 24 figs. 12–14, pl. 25 fig. 16.

1965 *Limopsis chapmani;* Ludbrook, p. 83–4, pl. 1 figs. 1–9.

Type locality: Bird Rock Cliffs near Spring Creek, Torquay, Victoria; Jan Juc Formation.

Material: WAM 67.77, 69.107, 72.234, 72.255, 72.264, 74.535, 74.545, 74.546, 78.4090. NMV P40640, P40645.

Remarks: This is the most common bivalve at Walpole, the present recovery of 202 specimens comprising 7 articulated pairs, 101 left and 94 right valves. Shells appear to be somewhat smaller in size than the range of material figured by Ludbrook (1965) and though to a degree robust, could not be described as heavy, as noted by Singleton for the type. In Walpole specimens, sculpture is mainly and often wholly transverse; occasional specimens show weak radial threads variously distributed on the posterior, anterior and ventral areas. Length 12·0, height 13·2, inflation (one valve) 3·9 mm.

This is a highly variable species, with specimens ranging from small, highly convex valves with quadrate outline to large, shallow valves with rounded outline. Walpole specimens match the former, which is a common type in the upper part of the Brown's Creek Clay. There are 10 naticiform and 6 muriciform boreholes present in the material. A subspecies, *L. chapmani valida* Singleton, is present in the Victorian Early Miocene (Longfordian).

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Pallinup Siltstone, Jan Juc Formation; Late Eocene to Oligocene.

Limopsis (Limopsis) multiradiata Tate?

Material: WAM 67.78.

Remarks: A single juvenile valve, similar to *multiradiata*, has been recovered from Walpole. It is distinguished from *L. (L.) chapmani* by a more symmetrical, evenly rounded outline; a fine radial sculpture covers the whole valve. Details of the ventral margin are missing. We defer positive identification of this specimen until a wider range of material is available. The type of *Limopsis multiradiata* was obtained from the Adelaide (i.e., Kent Town) Bore between 45·7 and 66·4 m and has been refigured by Ludbrook (1965). The species occurs in the Blanche Point Formation at Aldinga Bay and in the Brown's Creek Clay of the Otway Basin.

Family Mytilidae

Genus **Septifer** Récluz 1848

Subgenus **Septifer** s. s.

Septifer (Septifer) sp. cf. **S. (S.) fenestratus** Tate

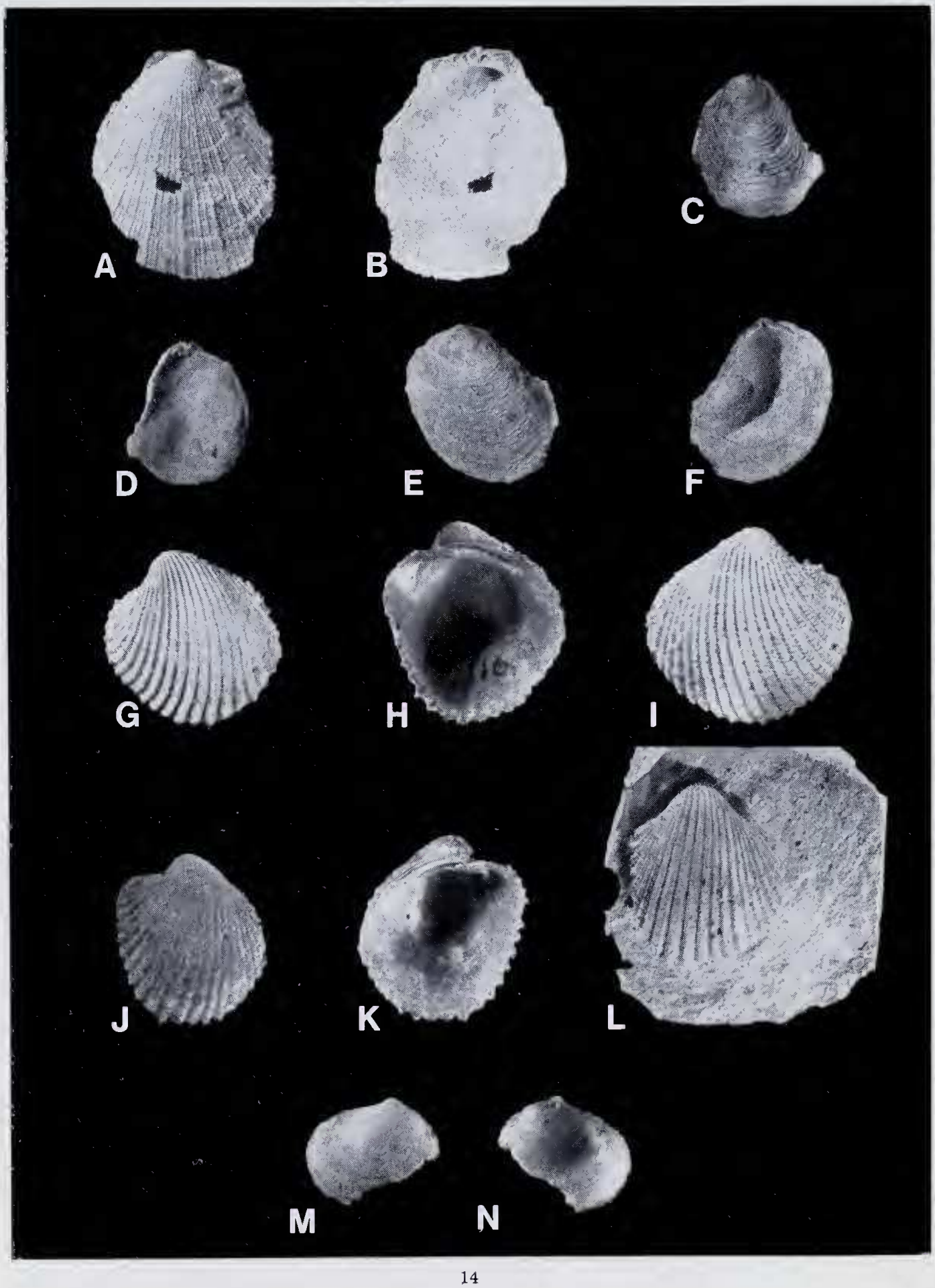
(Fig. 3 A–C)

Material: WAM 67.84, 69.109, 69.110, 74.551. NMV P40639, P40655.

Remarks: A species of *Septifer* s. s. from Walpole is represented by one substantially complete right valve and some fragments. It has a distinct, postero-dorsal marginal angulation of about 145°, a well defined antero-posterior ridge and a compressed, twisted umbo. The sculpture comprises bifurcate radial costae, relatively coarse on the median area and becoming more spaced and sharply defined dorsally near the umbo, where some fenestration develops from the additional presence of low transverse sculpture. Ventrally, the costae are numerous, fine and close; an elliptical area near the byssal gape bears transverse sculpture only. Growth pauses are indicated by the presence of low, transverse surface irregularities. Anterior adductor scar prominent, reniform and located terminally on a septum behind the umbo; posterior adductor scar poorly defined; pallial line close to the margin. The ligamental area is weakly excavate and about half the length of the dorsal margin; amphidetic teeth present behind the ligament. The margin is everted posteriorly and, where intact, shows internal crenulation. Length 16·0, height 10·5, inflation (one valve) 5·6 mm.

Of the two species of *Septifer* described from the Australian Tertiary, the Walpole material appears to be closer to the Balcombian *fenestratus* Tate, though the figure of the type of that species (Tate 1886, pl. 9 fig. 1) depicts a somewhat fine-ribbed and flattened shell. Other specimens of *fenestratus* from Muddy Creek in the collection of the National Museum of Victoria are more similar to the Walpole material. *S. (S.) subfenestratus* Basedow, described from a "pseudomorphous cast in glauconite" (Basedow 1904), possibly from the Blanche Point Formation, appears to differ from the Walpole shell in the absence of a distinct marginal angulation, the proportions of the umbo and umbo-ventral ridge and in details of the sculpture. The range of variation in *subfenestratus* being unknown, it is possible that the differences between it and the present material are due to ontogenic and/or intraspecific variation but this cannot be ascertained without further material from both South and Western Australia. One fragment in the present material has a muriciform borehole.

Figure 3. A, B. C—*Septifer* sp. cf. *S. fenestratus* Tate. WAM 69.109. RV, x 2. D, E—*Vulsella laevigata* Tate. WAM 72.266. RV, x 2. F, G, H—*V. laevigata*. WAM 78.4091a. Pair showing RV, antero-dorsal and postero-dorsal aspects, x 3. I, J—*Plicatula* sp. WAM 67.79b. LV, x 2.3. K, L—*Plicatula* sp. WAM 67.79a. RV, x 2 (77.79a, b are a pair).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Family Malleidae
Genus **Vulsella** Roeding 1798
Vulsella laevigata Tate
(Fig. 3 D–H)

1886 *Vulsella laevigata* Tate: p. 122, pl. 3 figs. 3a–b.

Type locality: Glauconitic limestone at the base of Witton Bluff, South Australia; Tortachilla Limestone.

Material: WAM 72.266, 74.536, 74.550, 78.4091. NMV P40641, P40650.

Remarks: Specimens from Walpole comprise a left and right valves, 6 small articulated pairs and some fragments. The umbos are opisthogyrate, prominent, acute and are separated by a deep ligamental area with a prominent, triangular, median pit. Length 5·5, height (estimated) 10·0, inflation (two valves) 3·5 mm. The Walpole material compares well with a topotype in the collection of the NMV. The species is uncommon at Walpole. One shell (fig. 3D) features a gastropod borehole with a bevelled margin, apparently naticiform; this is unexpected because modern *Vulsella* inhabit the interiors of sponges and other epifaunal situations, whereas the Naticidae are infaunal predators.

Stratigraphic range: Tortachilla Limestone, Pallinup Siltstone; Late Eocene.

Family Plicatulidae
Genus **Plicatula** Lamarck 1801
Subgenus **Plicatula** s. s.
Plicatula (Plicatula) sp.
(Fig. 3 I–L)

Material: WAM 67.79, 67.93, 69.108, 69.112, 69.113, 69.117, 72.267, 72.268, 74.537, 74.539, 74.552, 78.4092. NMV P40638, P52337.

Remarks: A small *Plicatula*, s. s., is not uncommon in the Walpole material, being represented by 3 articulated pairs, 36 left, 5 right valves and fragments. The shell is irregularly folded, compressed, oval and a little higher than long. The valves are thin, the right more convex and with a relatively large attachment area near the umbo; left valve more or less flat when juvenile, becoming a little concave or convex with growth. Sculpture of both valves transversely lamellose with hollow, raised, incurved scales and from fifteen to twenty irregular, often bifurcate, radial costae, weakly to moderately developed; costae are absent from the attachment area and from a corresponding part of the left valve. Adductor scars oval, centred in the postero-dorsal quadrant. Crurae thick, erect, with points directed upward somewhat as in *Spondylus*; weakly serrated. Cardinal area present on the right valve, absent on the left. Length 17·4, height 18·7, inflation (two valves) 8·5 mm.

The Walpole specimens differ from *P. ramulosa* Tate from the Lower Miocene Freestone Cove Sandstone of Table Cape (Tate 1898) by the relatively thin valves and finer, more numerous costae. The three nominal species of *Plicatula* erected by Chapman (1922) from the Miocene Muddy Creek Marl ("Lower Beds") of the Otway Basin seem more probably to represent a single variable species, close to and possibly conspecific with *ramulosa*. All of these Miocene forms have fewer more widely spaced costae than the Walpole material; their relationships require clarification and until this is done we defer further consideration of the taxonomic status of the Walpole specimens.

The preponderance of the unattached left valves (36 to 5 rights) in the Walpole material is noteworthy. It seems that the right valves have tended to remain attached to substrates and that there has been some post-mortem transportation of the lefts.

There are 11 muriciform boreholes present on our material, a predation rate of 1:4. Ten of these boreholes occur on the upper, left valve; the other is on a right (WAM 72.267a), being positioned near the raised anterior margin and well clear of the area of attachment.

This appears to be the first record of the genus from the Eocene of Australia. A Late Cretaceous plicatulid from the Gingin Chalk of the Perth Basin, attributed to *Plicatula* by Feldtmann (1963), appears to be a species of the genus *Atreta* Etallon and not related to the Walpole material.

We draw attention to the fact that the valve orientations for *Plicatula* (*Plicatula*) *marginata* Say in the Treatise on Invertebrate Paleontology N (1), p. N377–8, fig. C98 1 a–e are recorded incorrectly; a, b and e are right valves, c and d are lefts.

Family Spondylidae
Genus **Spondylus** Linnaeus 1758
Spondylus sp. cf. **S. gaderopoides** McCoy
(Fig. 4 A,B)

Material: WAM 67.83, 72.269. NMV P40642, P52338.

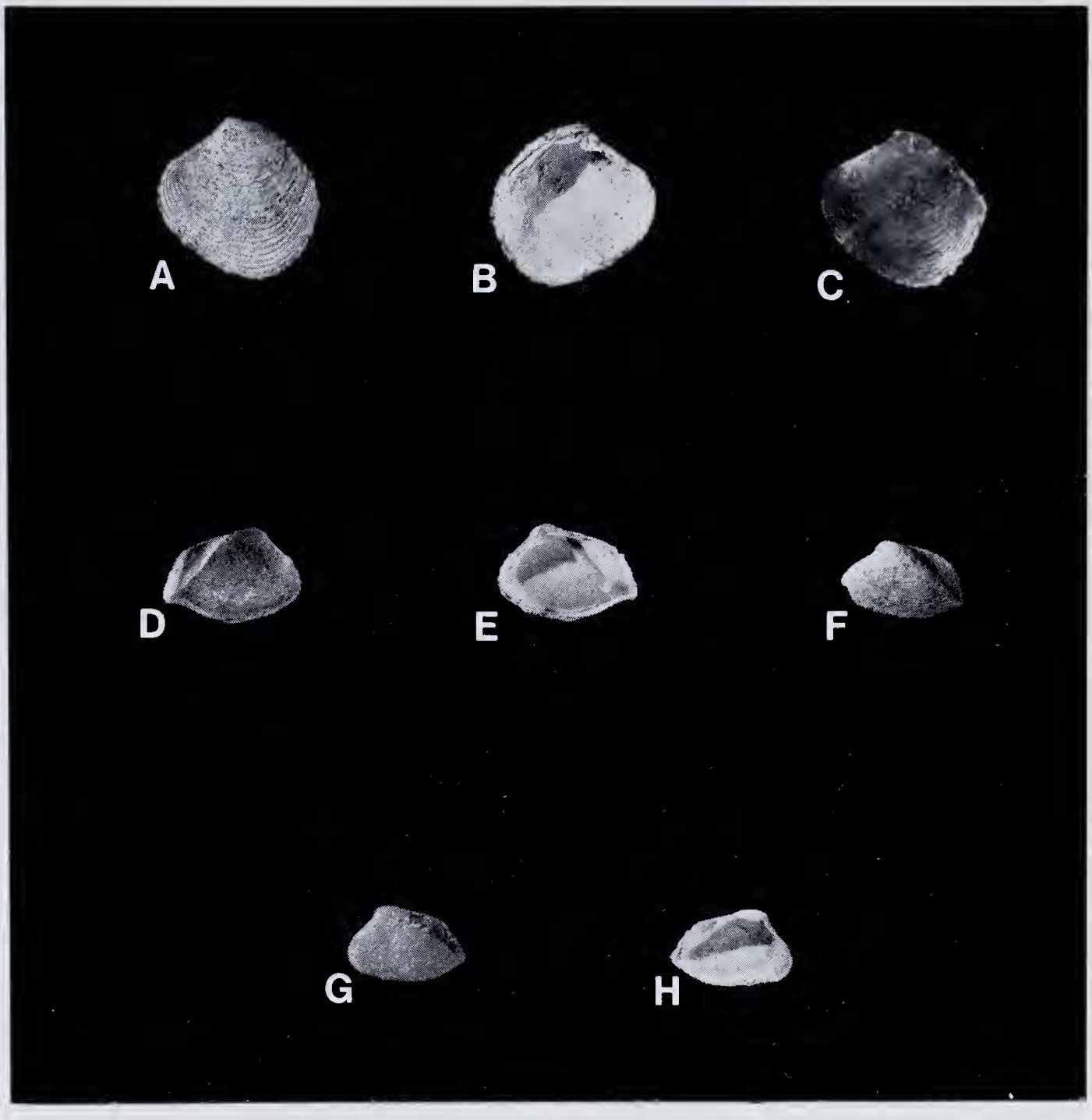
Remarks: One complete and 5 incomplete left valves, 4 of which are mere fragments, represent a species of *Spondylus* close to *S. gaderopoides* McCoy at Walpole. The figured specimen is small, thin, moderately inflated, oblique and prosogyrate; costae are numerous, fine, of 3 orders, the most prominent numbering about 12 and bearing low, spinose projections; the intercostal spaces bear weak, transverse growth lamellae. The auricles are unequal, the posterior larger. Crurae are well spaced within a rather short dorsal margin; ventral margin, where retained, weakly crenulated. Adductor scar located in a posterior-central position; poorly preserved. Length 13·1 (estimated), height 16·2, inflation (one valve) 3·5 mm.

Comparison of the limited Walpole material with a range of mature specimens of *S. gaderopoides* from the type locality shows that the Walpole shells lie within their range of variation. However as all of the present material is immature, we defer positive identification until a better range of specimens, including right valves, is available.

S. gaderopoides was described (McCoy 1876, 1877) from the Oligocene Jan Juc Formation of Bird Rock Bluff, Torquay and subsequently recorded from several Eocene sources in southern Australia by Tate (1886, 1899) and Lowry (1970). The latter, while confirming Tate's record of the species from the Eocene Wilson Bluff Limestone, reported further occurrences from the Lower Miocene Abrakurrie Limestone and Colville Sandstone of the Eucla Basin.

One specimen in the Walpole material bears a muriciform borehole.

Figure 4.—A, B—*Spondylus* sp. cf. *S. gaderopoides* McCoy. WAM 72.269. LV, x 2. C, D *Dimya sigillata* Tate. WAM 74.553a. LV, x 3. E, F—*D. sigillata*. WAM 67.80a. LV, x 3. G—*Glans* (*Fasciculicardia*) *latissima* (Tate). WAM 67.85a. LV, x 2. H—*G.* (*F.*) *latissima*. WAM 69.116a. RV, x 2. I—*G.* (*F.*) *latissima*. WAM 74.554. RV, x 2.2. J, K—*G.* (*F.*) *latissima*. WAM 72.271a. LV, x 2. L—*Cardium arcaeformis* Chapman and Crespin. Latex cast of holotype, WAM 6048. LV, x 2. M, N—*Epicodakia* sp. WAM 78.4096b. LV, x 3.



Family Dimyidae

Genus **Dimya** Rouault 1850

Dimya sigillata Tate

(Fig. 4 C–F)

1886 *Dimya sigillata* Tate: p. 100-1, pl. 8 figs. 8a–b.

1895 *Dimyodon sigillata;* Bittner, p. 218.

1970 *Dimyodon sigillata;* Ludbrook in Lowry, fig. 21H.

1973 *Dimya sigillata;* Ludbrook, pl. 24 figs. 14-5.

Type locality: Localities cited by Tate (1886) are "*Turritella* clays and glauconite limestones, Aldinga; glauconite sands, Adelaide bore; chalk rock, Bunda Cliffs of the Great Bight". The first two records are from the Blanche Point Formation; the last, corresponding to the Wilson Bluff Limestone, is confirmed by Ludbrook in Lowry (1970).

Material: WAM 67.80, 74.553. NMV P40633, P40646.

Remarks: Six complete specimens, 1 fragmentary left and 3 fragmentary right valves represent this species in the Walpole material. One of the right valves shows weak internal ribbing but there is no trace of this on the interiors of any of the lefts. External radial sculpture is present only on the right valves; lefts are finely transversely lamellose with no trace of radial costae. Length 7·0, height 8·7, inflation (one valve) 2·7 mm.

Specimens from Brown's Creek in the collection of the NMV are small and exhibit only very weak radial sculpture; they more resemble Walpole specimens than those from Aldinga. We ascribe no taxonomic significance to these differences. The specimen from Albany listed by Chapman and Crespin (1934) as *Dimya*

dissimilis (Tate) [sic] has been located in the NMV collection registered number P42467. It is a small, poorly preserved external mould, apparently of a left valve, with a suggestion of radial sculpture but is not sufficiently well-preserved for certain, specific identification. The stratigraphic range of positively identified *D. dissimilis* is Janjukian to Bairnsdalian and we consider earlier records attributed to that species to be doubtful.

With its weak cardinal dentition and bilobed posterior adductor scar, *sigillata* seems better located in *Dimya* than in *Dimyodon*, as listed by Darragh (1970) and Ludbrook in Lowry (1970). Three specimens in the present material have been pierced by muriciform boreholes. A recent study of the Dimyidae is by Yonge (1978).

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Wilson Bluff Limestone, Pallinup Siltstone; Late Eocene.

Family Limidae

Genus **Limea** Bronn 1831

Subgenus **Gemellima** Iredale 1929

Limea (Gemellima)? sp.

Material: WAM 69.111.

Remarks: A small, poorly preserved and slightly deformed valve, probably a left, represents the genus and possibly the subgenus in the Walpole material. The presumed anterior side is a little more widely produced than the posterior. The umbo is prominent, tumid and prosogyrate, rising well above the dorsal margin; the beak is approximately median. Auricles are both small, the presumed anterior one the larger. Viewed hinge-down, the valve seems to have been deformed by compression across a NE—SW axis, one result of which may have been to deflect the umbo a little to the left (?anteriorly). There are about 22 prominent, raised radial costae, weakly scaled and equal in width to the interspaces, which are packed with fine, close, transverse costellae. The primary sculpture is continuous to the (presumed) anterior margin but details are not discernible on the posterior side. The ventral margin is strongly crenulated; details of the interior and dorsal margin are obscured by adherent silica. Length (antero-postero diameter) 3·4, height (umbo-ventral diameter) 5·5, inflation (one valve) 2·1 mm.

The affinities of this specimen are uncertain but appear to be tentatively with *Gemellima* Iredale, of which the type and only described species is *Limea* (*Gemellima*) *austrina* Tate, 1887. Its stratigraphic range is given as Early Pliocene to Holocene by Buonaiuto (1977). The Walpole specimen is relatively higher than Tate's species and may prove to be somewhat prosogyrate in the undeformed state. More positive identification is deferred until better specimens are available.

Stratigraphic range: Pallinup Siltstone; Late Eocene.

Limid, genus and species undetermined

Material: WAM 67.44.

Remarks: A piece of grey spongolite from Walpole shows on a weathered face a left valve of a species of Limidae. It is ovate, slightly oblique and bears about 60 evenly distributed, fine radial costae, equal in width to the interspaces and bearing traces of fine scales. The posterior auricle is the larger. Interior not visible. Length 15·0, height 20·0, inflation (one valve) 3·0 mm. Of the limid species described by Tate (1886, 1899) this appears to be closest to "*Lima*" *polynema*, but differs in the fewer costae (60 against 90). It may be a *Limea* or a *Limaria*, but this cannot be established without the internal characters. Rare at Walpole.

Family Lucinidae

Genus **Epieodakia** Iredale 1930

Epieodakia sp.

(Fig. 4 M, N)

Material: WAM 72.272, 78.4096. NMV P56029.

Remarks: A small lucinid, apparently an *Epicodakia*, is represented in the material from Walpole by 3 articulated pairs and a worn, fragmentary left valve. In most features (proportions, size, sculpture, hinge detail and pallial configuration), the fossils are broadly comparable to *Epicodakia consettiana* Iredale (= *Lucina minima* Tenison Woods), the type species of *Epicodakia*. Radial sculpture appears to be a little weaker on the fossil specimens and is most evident on the anterior and posterior extremities. Hinge details are available only for the left valve; 4b is thin, oblique; 2 much heavier, triangular but imperfectly preserved; AII well developed, stronger and more distant from the cardinals than PII. The anterior adductor scar is relatively long in the fossil species. Formal description is deferred until more and better preserved material, including the right valve, is obtained.

Tate (1887) described two lucinids, *Lucina araneosa* and *L. despectans* from the Middle Miocene of the Otway Basin, which Darragh (1970) refers to *Epicodakia*. Of these, the present species is closer to *E. despectans* but has finer and stronger radial and transverse sculpture and is not as strongly excavate in front of the umbo. The Walpole record is the first for the genus from the Eocene.

Stratigraphic range: Pallinup Siltstone; Late Eocene.

Family Carditidae

Genus **Glans** Mergerle 1811

Subgenus **Fasciculicardia** Maxwell 1969

Glans (Fasciculieardia) latissima (Tate)

(Fig. 4 G–L)

1886 *Cardita latissima* Tate: p. 153, pl. 2 fig. 5.

1927 *Venericardia latissima;* Chapman and Singleton, p. 118 9, pl. 11 figs. 22–3.

1934 *Cardium arcaeformis* Chapman and Crespin: p. 121, pl. 11 figs. 25–7.

1973 *Glans latissima;* Ludbrook, p. 247, pl. 24 figs. 11–12.

Type locality: Adelaide (i.e., Kent Town) Bore, South Australia (Tate 1886, Ludbrook 1973); Blanche Point Formation.

Material: WAM 67.29, 67.30, 67.31, 67.85, 69.116, 72.235, 72.271, 74.554, 74.555, 78.4093. NMV P40643, P40656.

Remarks: This is one of the more common species at Walpole, being represented by 12 articulated pairs, 32 right and 22 left valves. Specimens generally compare well with Tate's description and figure but there is some

Figure 5.—A, B—*Salaputium communis* (Tate). WAM 69.115. LV, x 2. C—*S. communis*. WAM 78.4094. LV, x 3. D, E—*Corbula* (*Caryocorbula*) *pixidata* Tate. WAM 74.558a. RV, x 2. F *C.* (*C.*) *pixidata*. WAM 74.558c. LV, x 2. G, H—*C.* (*C.*) *pixidata*. WAM 74.558b. LV, x 2.

noteworthy variation. Most are obliquely subquadrate and higher than long but an occasional one has a submedian umbo on a shell about as wide as high (see Fig. 4 I). A proportion of specimens is clearly deformed, probably due to compaction, and possibly some of the "variation" noted above may be so derived. In the majority of specimens, the radial costae (as in Tate's type) are narrower than the interspaces and bear spaced, erect scales but others have wider costae with closely packed transverse scales. These differences recall those noted in other Tertiary carditid species and attributed by Heaslip (1969) to sexual dimorphism. Rib counts in the present material range from 25–30, with a mean of 22 valves at 26·1. Length 14·6, height 14·1, inflation (one valve) 6·4 mm.

We have examined the type of *Cardium arcaeformis* Chapman and Crespin (WAM 6048, Fig. 4 L), a substantially complete external mould in grey spongolite from Albany, and consider it to be conspecific with *G. (F.) latissima*. It represents an obliquely subquadrate right valve of a form common at Walpole; the posterior side is somewhat flattened and compressed, possibly as a result of sediment compaction. Impressions of 25 radial costae are retained, a number which, in the original may have been exceeded slightly. Only vestiges of the lamellar scales remain as impressions, being more apparent at the anterior and posterior extremities. Such reduced sculpture is a feature of some Walpole specimens but whether this is due to mechanical erosion of the original carbonate shell, or to some imperfection of the silica-replacement process, is not clear.

The material contains 1 naticiform and 5 muriciform gastropod boreholes, suggesting that the species may have been epifaunal and associated with fine substrates. It is common and widespread throughout the Pallinup Siltstone.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Pallinup Siltstone; Late Eocene.

Family Crassatellidae

Genus **Salaputium** Iredale 1924

Salaputium communis (Tate)

(Fig. 5 A–C)

1896 *Crassatella communis* Tate in Tate and Dennant: p. 129 *nom. nov.* for *Crassatella astartiformis* Tate 1886 (*non* Nyst 1847)

1930 *Salaputium aldingensis* Finlay: p. 38 *nom. nov.* for *Crassatella corrugata* Tate 1886 (*non* Adams and Reeve 1850).

Type locality: Not precisely defined. Tate's localities were "Aldinga and Adelaide bore; R. Murray Cliffs; Muddy Creek and Schnapper Point". More than 1 species is likely to be covered by these records of Tate and we consider that the latter 3 (Miocene) localities should be disallowed for *S. communis*. The type locality for Tate's species *S. corrugata* is "Clays with *Turritella aldingae* at Blanche Point, Aldinga Bay".

Material: WAM 67.92, 69.115, 74.556, 78.4094. NMV P40632, P40649.

Remarks: Three articulated pairs, 3 lefts and a right valve represent this species from Walpole. Compared with material from South Australian and Victorian localities, they are more finely ribbed, having about 24 transverse costae in height of 6·5 mm. The minute radial striae present in Tate's material have not been observed in Walpole shells. Length 6·9, height 6·5, inflation (both valves) 3·7 mm.

In our view, this is a somewhat variable species, particularly in the sculptural features. We have examined Tate's types of *communis*, which show little variation in this respect, and have compared them with a wider and more representative range of material from the Late Eocene of South Australia and Victoria in the NMV collection. *S. aldingensis* is based on a specimen having relatively few coarse ribs and all grades can be seen between this and the typically finer more numerous ribbing of *communis*. Transverse sculpture on South Australian specimens in the NMV collection varies from 9 coarse (*aldingensis* form) to about 13 fine ribs (*communis* form). Victorian specimens, though more variable than those from South Australia, tend also to be coarser in sculpture than the Walpole shells but at present, we ascribe no taxonomic significance to these differences. Study of a wider range of material, both from south-western and south-eastern Australia should serve to clarify this question.

Other species of *Salaputium* (*lamellata* and *abbreviata* both of Tate and *corioensis* Chapple) occur in the Eocene, Oligocene and Miocene of South Australia and Victoria (Darragh 1970). A generic revision of the entire group may now be warranted.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Pallinup Siltstone; Late Eocene.

Family Cardiidae

Genus **Vepricardium** Iredale 1929

Subgenus **Hedecardium** Marwick 1944

Vepricardium (Hedecardium) moniletectum (Tate)?

1887 *Cardium moniletectum* Tate: p. 151, pl. 14 figs. 3a–b.

Type locality: Adelaide (i.e., Kent Town) Bore, South Australia; Blanche Point Formation.

Material: WAM 67.27.

Remarks: A natural mould of a fragment of a valve agrees well with Tate's original description and figure. Positive identification is deferred until further material becomes available. *V. moniletectum* occurs in the Blanche Point Formation of the St. Vincent Basin.

Family Glossidae

Genus **Glossus** Poli 1795

Subgenus **Miocardiopsis** Glibert 1936

Glossus (Miocardiopsis) sp.

Material: WAM 67.89, 74.559, 78.4095. NMV P52339.

Remarks: A *Glossus*, probably of the subgenus *Miocardiopsis*, is represented in the Walpole material by 2 deformed pairs and 2 fragmentary left valves. It appears to be an undescribed species and the first record for the family from the Australian Eocene; previous records of the subgenus are confined to the Eocene of Europe, according to Keen and Casey (1969). Formal description is deferred until a range of better material is available.

From the specimens to hand, the shell is small, compressed, inequilateral and sub-quadrate in outline. The umbo is prominent, prosogyrate but not twisted and located at about the anterior third. Dorsal margin arched, lower on the anterior side; anterior margin short, rounded, merging into a gently rounded rather long ventral margin; posterior margin obliquely truncate, meeting the ventral edge at an angle of about 90°. Postero-ventral ridge well-defined (apparently accentuated by deformation in the only entire specimen) and with a corresponding internal groove. Lunule apparently absent; escutcheon well defined, bordered by a distinct angulation and lightly transversely striate.

The posterior slope bears fine, close transverse sculpture; median sculpture similar but much finer and crossed by very faint, discontinuous radial striae. Ligamental groove marginal, nymph strong, located well behind the umbo. Left valve with 2 widely divergent cardinals behind the umbo and a distant posterior lateral. Adductor and pallial attachment scars not visible; anterior features generally obscure. Length 13·6, height 10·9, inflation (one valve) 3·5 mm.

The specimen listed by Chapman and Crespin (1926, 1934) as "*Arca* sp", from Albany has been located in the NMV collection (P42476). It is not an arcid but could possibly represent a glossid such as the present species.

Stratigraphic range: Pallinup Siltstone; Late Eocene.

Family Veneridae

Genus **Dosina** Gray 1835

Subgenus **Dosina** s. s.

Dosina (Dosina) multilamellata (Tate)

1887 *Chione multilamellata* Tate: p. 154–5, pl. 15 figs. 6a–b.

1934 *Callanaitis cainozoicus* (Tate) (sic); Chapman and Crespin, p. 126.

1973 *Dosina* (*Dosina*) *multitaeniata* (Tate); Ludbrook, pl. 24 figs. 18, 19.

Type locality: Adelaide (i.e., Kent Town) Bore, South Australia; Blanche Point Formation.

Material: WAM 67.90, 78.4097.

Remarks: Four small articulated pairs and some fragments represent this species from Walpole. They have been compared with specimens from Blanche Point and Brown's Creek in the collection of the National Museum of Victoria and found to be very close.

We have located in the WAM collection specimen 5435 from "Hassell's Road, 10 miles from Cheyne Beach", which appears to be one of those listed by Chapman and Crespin as "*Callanaitis cainozoicus* (Tate)", evidently an error for "*Callanaitis cainozoicus* (Tenison Woods), a Table Cape species. The specimen, a piece of pale brown siltstone, bears an external impression consistent with the present species.

The name *Chione multitaeniata* was erected by Tate in Tate and Dennant (1896 p. 129, footnote) as a replacement for "*C. multilamellata* non Br.". An intensive search through the literature has failed to find any name, which could be interpreted as a homonym. In view of the fact that the author and date of the name were not cited, *C. multitaeniata* is regarded as an invalid name.

The material shows 1 naticiform and 1 muriciform borehole. Uncommon at Walpole.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Pallinup Siltstone, Jan Juc Formation, Freestone Cove Sandstone; Late Eocene to Early Miocene.

Family Corbulidae

Genus **Corbula** Bruguière 1797

Subgenus **Caryocorbula** Gardner 1926

Corbula (Caryocorbula) pixidata Tate

(Fig. 5 D–H)

1887 *Corbula pixidata* Tate: p. 177, pl. 17 figs. 12a–b.

1973 *Corbula* (*Caryocorbula*) *pixidata;* Ludbrook. p. 247

Type locality: Blanche Point, Aldinga, South Australia;

Material: WAM 67.91, 72.273, 74.558, 78.4098. NMV P40630, P40652.

Remarks: A series of 9 articulated pairs, 1 right and 7 left valves from Walpole agrees closely with the original description and topotypes of *pixidata*. Both valves are posteriorly carinate and there is little or no pallial sinus. Length 9·5, height 6·3, inflation (one valve) 2·4 mm. One valve in the collection has a muriciform borehole. The species is uncommon at Walpole.

Stratigraphic range: Blanche Point Formation, Brown's Creek Clay, Pallinup Siltstone; Late Eocene.

Family Verticordiidae

Genus **Verticordia** Sowerby 1844

Subgenus **Verticordia** s. s.

Verticordia (Verticordia) sp.

Material: WAM 67.86.

Remarks: A minute single right valve represents the genus in the present material. It has 16 costae, a little narrower than the interspaces, and bearing low spines on the crests only. Lunule small; hinge poorly preserved. Of the species of *Verticordia* described from the Australian Tertiary by Tate (1887) and Pritchard (1901), the Walpole specimen differs in shape and number of costae. It appears to be undescribed but must so remain until further specimens are collected. Length 2·6, height 2·6 mm. This appears to be the first record for the genus from the Eocene of Australia.

Stratigraphic range: Pallinup Siltstone; Late Eocene.

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